

heads can be obtained.

Seventh Embodiment: improvement in thermal stability and mirror reflectivity, and reduction in magnetostriction

From the viewpoint of improving the thermal stability and the mirror reflectivity and of reducing the magnetostriction, the seventh embodiment of the invention is described below.

Prior to introducing this embodiment, the problems which we, the inventors have recognized in the process of achieving this embodiment are mentioned.

For practical use of high-performance spin valve films (hereinafter referred to as SV films), we, the inventors have recognized various problems such as the following:

- (1) Poor thermal stability (especially in initial annealing).
- (2) Insufficient MR ratio for much more increasing reproduction sensitivity.
- (3) When the free layer is a single-layered CoFe alloy layer capable of giving relatively large MR ratio, then its magnetostriction control is impossible, and good soft magnetic characteristics could not be obtained.

These problems with SV films are mentioned in detail hereunder.

(1) Thermal stability:

As the general constitution of SV films, known is a few nm NiFe/about 1 nm Co or a few nm NiFe/about 1 nm CoFe. The

SV film structure with such a free layer includes;

- (a) 5 nanometer Ta/10 nm NiFe/1 nm Co/3 nm Cu/2 nm CoFe/7 nm IrMn/5 nanometer Ta,
- (b) 5 nanometer Ta/2 nm Cu/3 nm CoFe/3 nm Cu/2 nm CoFe/7 nm IrMn/5 nanometer Ta.

After annealed at 250°C for 4 hours or so, the MR ratio of those SV films decreases by about 20 % or more in terms of the relative ratio based on the as-deposited films. For example, the MR ratio in the as-deposited SV film (a) is 6.4 %, but, after annealed at 250°C for 3 hours, the MR ratio therein is 4.7 %. Thus, the reduction in the MR ratio after the annealing is more than 20 % in terms of the relative ratio based on the as-deposited film. The annealing step is indispensable in fabrication of heads. The MR ratio in the as deposited SV film (b) not having a free layer of NiFe is 8.1 %, but, after annealed at 250°C for 3 hours, the MR ratio therein is 6.5 %. Even in the film (b), the reduction in the MR ratio after the annealing is about 20 % in terms of the relative ratio based on the as-deposited film. At present, known is no means of preventing the MR ratio reduction without sacrificing the magnetic characteristics, or that is, any measure for improving the thermal stability for the MR ratio in SV films is not known.

For magnetic heads for high-density recording, desired are SV films with higher MR ratio. However, as mentioned above, the MR ratio in the conventional SV films in the as-deposited

condition is greatly lowered in thermal annealing that is indispensable to fabrication of heads. This problem must be solved by all means for developing MR heads for high-density recording on a level of 10 Gdpsi or more.

(2) Increase in MR ratio by specular reflection:

In order to attain high MR ratio, another important matter, in addition to the means how to keep the original MR ratio in the as-deposited condition still after thermal treatment as discussed in the previous (1), is how to increase the peak value of the MR ratio or, even though the as-deposited film could not have a full-potential MR ratio, how to realize a film capable of having good MR ratio after thermal treatment.

Regarding the GMR effect, the frequency of spin-dependent scattering increases with the increase in the number of laminated layers of magnetic layers/nonmagnetic layers in a laminate film within the range narrower than the mean free path of electrons, and the increase in the number of laminated layers in the film brings about large MR ratio in the film. However, in the constitution of the GMR film that is actually used in practical heads, such as the constitution of SV films, there exist only the units of pinned magnetic layer/nonmagnetic spacer layer/free layer. In general, therefore, the thickness of the GMR film including SV films is smaller than the mean free path of electrons, which is against the MR ratio increase to which the invention is directed.